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UNRAVELLING THE CONSTRAINTS OF RAINFED GROUNDNUT PRODUCTION: AN EXPLORATORY FACTOR ANALYSIS AMONG FARMERS IN VELLORE DISTRICT, TAMIL NADU

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ABSTRACT:
Rainfed groundnut cultivation is an important agricultural activity in semi-arid and drought-prone regions, where farm production is influenced by rainfall variability, resource limitations, input costs, financial access, market conditions and institutional support. Understanding the interrelated nature of these constraints is essential for developing location-specific interventions. The purpose of the current investigation was to determine and classify the underlying constraints encountered by rainfed groundnut growers in the Vellore district of Tamil Nadu. The 120 rainfed groundnut growers were randomly selected. A five-point Likert-type scale, ranging from 1 (not a constraint) to 5 (very severe constraint), was employed in order to evaluate twenty constraint statements. Factors with eigenvalues greater than one were kept after SPSS Varimax rotation exploratory factor analysis. The data's eligibility for factor analysis was validated by the Kaiser-Meyer-Olkin measure of sampling adequacy of 0.776, along with the significance of Bartlett's test of sphericity (χ^2 =1090.616, df =190, p <0.001). Together, these five factors accounted for 68.661% of the variance. Financial constraints, climate and water constraints, marketing constraints, input and production constraints, and institutional constraints were the aspects examined. The range of factor loadings was 0.672 to 0.873. Inadequate technical assistance (0.847), insufficient water supply (0.839), and limited awareness of superior rainfed technology (0.873) had the largest loading. The findings demonstrate that the constraints of rainfed groundnut growers are multidimensional and interconnected, requiring integrated interventions covering water management, affordable inputs, institutional finance, market support and strengthened agricultural extension.

KEYWORDS: Groundnut, rainfed agriculture, constraints, exploratory factor analysis, climate variability.

INTRODUCTION

Groundnut (Arachis hypogaea L.) is an important oilseed crop in India and is widely cultivated under rainfed conditions. Rainfed crop performance is inherently reliant on the timing and distribution of rainfall, soil moisture availability and the capacity of farmers to respond to climatic uncertainty. Rainfed production systems are particularly vulnerable to climatic variability because limited irrigation buffers are available when rainfall becomes erratic or dry spells occur during critical crop-growth stages. Studies on Indian rainfed systems have demonstrated that rainfall and temperature are important determinants of crop suitability and that improved varieties and better water-management infrastructure can contribute to resilience (Singh et al., 2017).

Groundnut production in India also faces structural challenges beyond climatic risk. The groundnut sector has been characterized by an uncertain production environment, limited resource availability among smallholders and inadequate adoption of improved technologies (Reddy and Bantilan, 2012). In the case of groundnut, production constraints such as water stress, high input costs, inadequate availability of improved varieties and pest and disease incidence can directly affect productivity. Research in different groundnut-growing regions of India has similarly reported problems associated with seed availability, input costs, production technology, credit, drought and market prices (Veeraiah et al., 2019; Shasani et al., 2020; Teja et al., 2022). Climate variability further intensifies these production challenges. Farmers in dryland regions have reported changes in rainfall and temperature and associated effects on agricultural livelihoods. In Bundelkhand, India, farmers identified low irrigation coverage and weak livelihood conditions as important barriers to adaptation, while access to credit and insurance positively influenced adaptation decisions (Singh, 2020). Similarly, drought-prone farming communities in Maharashtra reported declining crop yields, groundwater depletion and income losses associated with drought, highlighting the importance of locally appropriate adaptation and mitigation measures (Udmale et al., 2014). Recent evidence from India also indicates that adaptation decisions have been impacted by economic, institutional and informational factors (Bahinipati et al., 2024; Nivetha and Mohanraj, 2026).

The availability of inputs represents another important dimension of agricultural constraints. Timely access to quality seed, fertilizers and plant-protection inputs is essential for achieving potential productivity. Studies on climate-smart agriculture in India have shown that high input costs and limited knowledge can restrict the adoption of improved practices (Hebsale Mallappa and Pathak, 2023). In groundnut production, limited access to improved seed and inadequate extension support have been reported as important constraints among farmers in Telangana and Odisha (Bhavani and Koghare, 2025; Shasani et al., 2020).

Financial limitations can further constrain farmers' capacity to respond to climatic and production risks. Credit availability enables farmers to purchase inputs, invest in water-management technologies and implement timely adaptation measures. Evidence from India indicates that credit, insurance and irrigation access can influence farmers' adaptation decisions (Singh, 2020), while institutional support involving credit, subsidies, along with training can enhance the adoption of climate-smart technologies (Bahinipati et al., 2024). Marketing constraints constitute another important challenge in groundnut production. Price instability, inadequate market access, transportation costs and limited market information can reduce farmers' returns. Groundnut marketing studies have documented low prices, price fluctuations, intermediary-related problems, transportation constraints and limited knowledge of market opportunities (Chaithanya et al., 2024). Groundnut value-chain research has likewise emphasized inadequate institutional mechanisms for input supply, high seed costs, insufficient storage and low remunerative prices as important structural issues (Devi et al., 2017).

Institutional and extension support is particularly important in rainfed farming because farmers need timely technical information to respond to changing climatic and production conditions. Climate-smart agriculture research in India has established the importance of extension services, training, farmer field schools and institutional support in facilitating adoption (Aryal et al., 2018; Bahinipati et al., 2024). Challenges to climate adaptation might additionally arise from limited knowledge, inadequate resources, weak information systems and institutional fragmentation (Azhoni et al., 2017a; Azhoni et al., 2017b). Although individual constraints have been documented in earlier studies, farmers' constraints are rarely isolated.

Climate, production, financial, marketing and institutional constraints can interact and reinforce each other. Therefore, examining the underlying structure of these constraints can provide a more meaningful basis for intervention planning. Exploratory Factor Analysis (EFA) is particularly useful for decreasing a relatively large set of correlated variables into a smaller number of interpretable dimensions (Fabrigar et al., 1999; Williams et al., 2010). Against this background, current research aimed to evaluate and classify the underlying dimensions of constraints faced by rainfed groundnut growers in Vellore district of Tamil Nadu using Exploratory Factor Analysis.

MATERIALS AND METHODS

Study area and respondents

The study was undertaken in Vellore district of Tamil Nadu. The district has a significant dependence on rainfed agriculture, and groundnut constitutes an important crop in the rainfed farming system. The study focused on farmers cultivating groundnut under rainfed conditions. Gudiyatham, Pernambut, and K.V. Kuppam were the three blocks chosen for research which was shown in Fig 1. From every block, two villages were chosen. The study included 120 rainfed groundnut growers. Using simple random sampling, twenty responders were chosen from each of the six chosen communities. Primary data were acquired in May–July 2026 using organized personal interviews.

Measurement of constraints

Twenty statements representing major constraints associated with rainfed groundnut cultivation were included in the interview schedule. The statements covered climatic and water-related, input and production, financial, marketing and institutional dimensions. Farmers' perceptions were recorded employing five-point Likert-type severity scale (1=Not a constraint; 2=Less severe; 3=Moderately severe; 4=Severe; and 5=Highly severe). The statements were presented to respondents in mixed order to minimize the possibility of respondents anticipating or identifying predetermined dimensions.

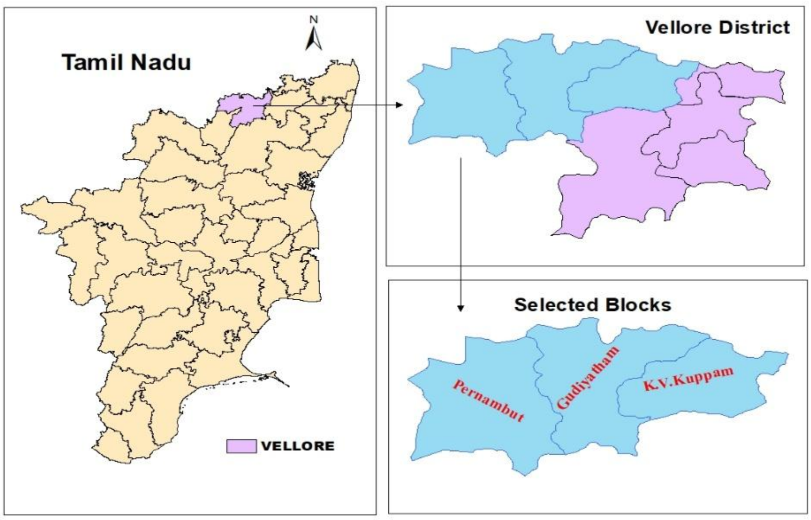

Fig 1. Map showing study area

Exploratory Factor Analysis

For evaluating underlying dimensions among the 20 constraint statements, an exploratory factor analysis took place employing SPSS. The data's adequacy for factor analysis was assessed employing Bartlett's test of sphericity and Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. Employing the Kaiser criterion, factors with eigenvalues larger than one were kept. Interpretable factorial structure was obtained utilizing varimax rotation. Variables were grouped under the factor on which they showed their highest loading, while the conceptual similarity of the variables was also considered in naming the extracted factors. Such use of factor analysis for reducing correlated constraint variables into broader dimensions has been demonstrated in agricultural and climate-adaptation research (Fabrigar et al., 1999; Williams et al., 2010; Pickson and Ge, 2021).

Results And Discussion

Suitability of the data for factor analysis

Table 1 displays the outcomes of the KMO and Bartlett's test. The correlation pattern between variables was appropriate for factor analysis, as demonstrated by KMO value (0.776). The correlation matrix was significantly different from identity matrix, as demonstrated by the highly significant Bartlett's test of sphericity (χ^2=1090.616; df =190; p<0.001). Therefore, the 20 constraint variables contained sufficient common variation to proceed with factor extraction.

Table 1. Kaiser-Meyer-Olkin and Bartlett's test of sphericity

Kaiser-Meyer-Olkin test	**KMO Measure of sampling adequacy**	**0.776**
Bartlett's test of sphericity	Approximate Chi-Square	1090.616
	Df	190
	Significance value	<0.001

The adequacy of the dataset is also consistent with established recommendations for exploratory factor analysis, where assessment of sampling adequacy as well as inter-item correlations is considered an essential preliminary step (Fabrigar et al., 1999; Williams et al., 2010).

Extraction of underlying factors

Five factors were kept since they had eigenvalues larger than one. First factor elucidated 25.399% of variance, with an eigenvalue of 5.080. Given an eigenvalue of 2.867, the second factor accounted for 14.334% of variance. A third factor, having eigenvalue of 2.371, explained 11.854% of variance. The fourth and fifth factors had eigenvalues of 1.809 and 1.607, explaining 9.045 and 8.037 per cent, respectively. Together, the five factors explained 68.661% total variance. Table 2 shows that the extracted dimensions captured a substantial proportion of the original 20 constraint statements.

The emergence of five interpretable dimensions is consistent with earlier agricultural constraint studies in which factor analysis has been used to reduce numerous farmer-perceived problems into broader technical, institutional, economic and environmental dimensions. For example, climate-adaptation studies have identified separate institutional, technical, financial, information and resource-related dimensions among farmers (Bryan et al., 2009; Deressa et al., 2009; Antwi-Agyei et al., 2014).

Table 2. Eigenvalues of the variables

Factor	**Eigenvalue**	**Percentage of variance**	**Cumulative variation (%)**
I	5.080	25.399	25.399
II	2.867	14.334	39.732
III	2.371	11.854	51.587
IV	1.809	9.045	60.631
V	1.607	8.037	68.661

Factor I – Climate and water constraints

The first factor was labelled Climate and water constraints. It comprised four variables: erratic and inadequate rainfall, prolonged dry spells during crop growth, inadequate water availability and limited access to farm water-harvesting facilities. Range of factor loadings 0.672 - 0.839. Inadequate water availability noted the highest loading (0.839), followed by erratic and inadequate rainfall (0.799) and prolonged dry spells during crop growth (0.788) which was shown in table 3.

Table 3. Factor I – Climate and water constraints

S. No.	**Constraint**	**Factor loading**
1.	Erratic and inadequate rainfall	0.799
2.	Prolonged dry spells during crop growth	0.788
3.	Inadequate water availability	0.839
4.	Limited access to farm water-harvesting facilities	0.672

The factor represents the close relationship between rainfall uncertainty and farmers' access to water resources. This finding is particularly relevant to rainfed groundnut cultivation because the crop is exposed to rainfall variability without the buffering capacity provided by assured irrigation. Research on rainfed agriculture in India has demonstrated the vulnerability of rainfed production to climatic changes and highlighted the importance of drought-tolerant varieties and irrigation infrastructure (Singh et al., 2017). Similarly, recurring drought in Maharashtra was associated with reduced crop yields, groundwater depletion and income losses among farming households (Udmale et al., 2014).

The importance of water stress in groundnut production has also been reported in the Saurashtra region, where water stress was identified as a major abiotic constraint affecting groundnut production (Dhandhalya and Shiyani, 2009). These findings support the emergence of climate and water constraints as the first underlying dimension in the present study.

Factor II – Input and production constraints

The second factor was identified as Input and production constraints. Four statements loaded on this factor: high cost of fertilizers and plant protection inputs, high cost of seed and planting materials, timely non-availability of quality inputs and incidence of pests and diseases. Factor loadings ranged from 0.737 to 0.831. The highest loading was recorded by high cost of seed and planting materials (0.831), followed by high cost of fertilizers and plant protection inputs (0.821) (Table 4).

Table 4. Factor II – Input and production constraints

S. No.	Constraint	Factor loading
1.	High cost of seed and planting materials	0.831
2.	High cost of fertilizers and plant protection inputs	0.821
3.	Timely non-availability of quality inputs	0.800
4.	Incidence of pests and diseases	0.737

The results suggest that farmers' production difficulties arise from both the cost and timely availability of inputs, together with biological production risks. Groundnut farmers in Odisha have reported inadequate knowledge, credit limitations, fluctuating market prices and lack of awareness of improved technology as important constraints (Shasani et al., 2020). Similarly, recent research in Telangana identified inadequate access to improved or pure seed varieties and inadequate extension services among important constraints faced by groundnut growers (Bhavani and Koghare, 2025).

Reddy and Bantilan (2012) also emphasized the importance of improved varieties, low-cost technologies and improved seed systems for enhancing the competitiveness and efficiency of India's groundnut sector. The present findings therefore reinforce the need for timely access to quality seed and affordable production inputs as part of an integrated strategy for improving rainfed groundnut productivity.

Factor III – Financial constraints

The third factor was labelled Financial constraints and consisted of high cost of cultivation, inadequate availability of institutional credit, high interest burden on borrowed capital and insufficient working capital for crop production. Factor loadings ranged from 0.792 to 0.839, exhibiting high cost of cultivation recording the highest loading (0.839) (Table 5).

Table 5. Factor III – Financial constraints

S. No.	Constraint	Factor loading
1.	High cost of cultivation	0.839
2.	Inadequate availability of institutional credit	0.811
3.	High interest burden on borrowed capital	0.813
4.	Insufficient working capital for crop production	0.792

The emergence of a distinct financial factor indicates that economic constraints constitute an important dimension of farmers' production problems. In rainfed farming, financial limitations may become particularly important because climatic uncertainty increases the risk associated with farm investment. Farmers with limited liquidity may find it difficult to purchase quality inputs or invest in water-management and climate-resilient technologies.

Singh (2020) found that access to credit and insurance positively influenced climate adaptation decisions among farmers in Bundelkhand. Similarly, research on climate-smart agriculture in eastern India reported that credit availability interacted positively with landholding in influencing adoption, while access to subsidies and institutional extension support could strengthen adoption. These findings are consistent with the present factor structure and emphasize that improving access to affordable institutional finance should form an integral part of rainfed agricultural resilience strategies.

Factor IV – Marketing constraints

The fourth factor was named Marketing constraints. The factor included low and fluctuating market prices, inadequate market access, high transportation cost to market and limited access to reliable market information. Factor loadings ranging 0.732 - 0.820, with low and fluctuating market prices recording the highest loading (0.820) (Table 6).

Table 6. Factor IV – Marketing constraints

S. No.	Constraint	Factor loading
1.	Low and fluctuating market prices	0.839

2.	Inadequate market access	0.811
3.	High transportation cost to market	0.813
4.	Limited access to reliable market information	0.792

The findings demonstrate that farmers' marketing problems involve both price-related and transaction-related constraints. Price fluctuations can increase income uncertainty, while transportation costs and limited market access can reduce the effective price received by farmers. Limited access to market information can further weaken farmers' bargaining capacity.

Groundnut marketing research in Kadapa district identified low prices, price fluctuations, intermediary-related problems, inadequate market information, transportation constraints and poor market access as major marketing problems (Chaithanya et al., 2024). Similarly, research on the groundnut value chain has emphasized low remunerative prices, inadequate institutional mechanisms, high seed costs and limited storage as important constraints affecting the profitability of the crop (Devi et al., 2017). Thus, the emergence of marketing constraints as a separate factor highlights the need to consider market access and price realization alongside production interventions.

Factor V – Institutional constraints

The fifth factor was identified as Institutional constraints. It consisted of inadequate technical guidance, limited awareness of improved rainfed technologies, inadequate access to extension services and limited availability of demonstrations and training. Range of factor loadings was 0.711 to 0.873. Inadequate technical guidance (0.847), along with limited awareness of enhanced rainfed technologies (0.873), had the highest loading (Table 7).

Table 7. Factor V – Institutional constraints

S. No.	Constraint	Factor loading
1.	Inadequate technical guidance	0.847
2.	Limited awareness of improved rainfed technologies	0.873
3.	Inadequate access to extension services	0.799
4.	Limited availability of demonstrations/training	0.711

The high loadings observed for awareness, technical guidance and extension access indicate that institutional support represents an important underlying dimension of the constraints perceived by rainfed groundnut growers. This is particularly important in a changing climate, where farmers need timely and location-specific information on varieties, sowing windows, moisture conservation, pest management and other risk-management practices.

The adoption of some climate-smart agricultural practices is strongly influenced by availability to extension services and training, according to research conducted in Bihar (Aryal et al., 2018). In Gujarat, Hebsale Mallappa and Pathak (2023) found that small farmers who participated in extension programs and received agricultural information adopted climate-smart technologies. Additionally, findings in line with Azhoni et al. (2017a, 2017b), emphasizing knowledge, information accessibility, institutional fragmentation and resource limitations as important barriers to climate adaptation. Therefore, strengthening the last-mile extension system might perform essential part in addressing institutional constraints of rainfed groundnut growers.

Overall interpretation of the factor structure

The factor analysis revealed that farmers' constraints were organized into five interrelated dimensions: climate and water, input and production, financial, marketing and institutional constraints. The extracted dimensions jointly explained 68.661 per cent of total variance, demonstrating five-factor structure accounted for substantial proportion of variation in farmers' perceptions which was shown in table 8.

The findings demonstrate that farmers' constraints should not be considered as isolated problems. Rather, they represent a combination of biophysical, economic, market and institutional limitations. Similar multidimensional patterns have been documented in climate-adaptation research, where farmers' adaptive capacity is affected by physical resources, information, economic resources, human resources and technology (Pickson and Ge, 2021).

Table 8. Summary of extracted factors

Factor	Dimension	Eigenvalue	Variance explained (%)
I	Climate and water constraints	5.080	25.399
II	Input and production constraints	2.867	14.334
III	Financial constraints	2.371	11.854
IV	Marketing constraints	1.809	9.045
V	Institutional constraints	1.607	8.037
Total			68.661

The systematic review of Indian climate adaptation research by Nivetha and Mohanraj (2026) similarly identified institutional, economic and informational factors as important determinants and barriers to climate adaptation. The present study adds crop-specific evidence by demonstrating how these broader dimensions manifest among rainfed groundnut growers in a specific agro-climatic and institutional context.

CONCLUSION

The present research employed exploratory factor analysis for identifying the underlying dimensions of the challenges faced by rainfed groundnut growers in Tamil Nadu's Vellore area. The data's suitability for factor analysis was validated by a KMO value of 0.776 and significant Bartlett's test. A total of five factors explained 68.661% of the variance, all of which had eigenvalues greater than 1. Climate and water restrictions, production and input constraints, financial constraints, marketing constraints, and institutional constraints were the factors that were analyzed. Among the individual variables, limited awareness of improved rainfed technologies, inadequate technical guidance and inadequate water availability showed particularly high factor loadings.

The findings establish that the challenges faced by rainfed groundnut growers are multidimensional and extend beyond climatic risk alone. Sustainable improvement in rainfed groundnut production therefore requires coordinated interventions involving water management, affordable and timely inputs, institutional finance, market support and strengthened agricultural extension. A major implication of the study is that extension interventions should move from a single-constraint approach towards an integrated constraint-management approach. Increasing farmers' access to markets, financing, climate-resilient technology, and timely technical information can enhance their capacity to manage the risks associated with rainfed groundnut production.

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